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ABSTRACT

This booklet, one of a series developed by the Frederick County Board of Education, Frederick, Maryland, provides an instruction module for an individualized or flexible approach to secondary science teaching. Subjects and activities in this series of booklets are designed to supplement a basic curriculum or to form a total curriculum, and relate to practical process oriented science instruction rather than theory or module building. Included in each booklet is a student section with an introduction, performance objectives, and science activities which can be performed individually or as a class, and a teacher section containing notes on the science activities, resource lists, and references. This booklet outlines the application of Mendel's laws of genetics to human genetics. The estimated time for completing the activities in this module is 1-2 weeks. (SL)

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Human Genetics

AIDS TO INDIVIDUALIZE THE TEACHING OF SCIENCE

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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MINI-COURSE UNITS

BOARD OF EDUCATION OF FREDERICK COUNTY

1974

Marvin G. Spencer

SE 021 635

GRAPHIC ARTS DEPARTMENT - F.M.S.

HUMAN GENETICS - MENDEL'S LAWS APPLIED TO YOU!

Prepared by

Sharon L. Sheffield

Estimated Time for Completion

1-2 weeks

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Mini Courses for

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1974

FOREWORD

The writing of these instructional units represents Phase II of our science curriculum mini-course development. In Phase I, modules were written that involved the junior high disciplines, life, earth and physical science. Phase II involves senior high physical science, biology, chemistry, physics and science survey.

The rationale used in the selection of topics was to identify instructional areas somewhat difficult to teach and where limited resources exist. Efforts were made by the writers of the mini-courses to relate their subject to the practical, real world rather than deal primarily in theory and model building.

It is anticipated that a teacher could use these modules as a supplement to a basic curriculum that has already been outlined, or they could almost be used to make up a total curriculum for the entire year in a couple of disciplines. It is expected that the approach used by teachers will vary from school to school. Some may wish to use them to individualize instruction, while others may prefer to use an even-front approach.

Primarily, I hope these courses will help facilitate more process (hands on) oriented science instruction. Science teachers have at their disposal many "props" in the form of equipment and materials to help them make their instructional program real and interesting. You would be remiss not to take advantage of these aids.

It probably should be noted that one of our courses formerly called senior high physical science, has been changed to science survey. The intent being to broaden the content base and use a multi-discipline approach that involves the life, earth and physical sciences. It is recommended that relevant topics be identified within this broad domain that will result in a meaningful, high interest course for the non-academic student.

ALFRED THACKSTON, JR.
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HUMAN GENETICS - MENDEL'S LAWS APPLIED TO YOU!

Mendel's Laws when applied to peas can be (and often are) confusing and somewhat dull! You probably think that he was somewhat eccentric to get so caught up with garden peas - perhaps he was. The true excitment of Mendel's works is revealed when we take the laws or rules he formulated with peas and apply them to animals and then to ourselves! It is in the area of human genetics that students usually find themselves most involved because it is this area which applies to you!

Genetics of any type is difficult because we are dealing with some very inconsistent subjects - living things. But the most frustrating experiences are encountered when one is working on genetics problems at the human level. Part of this problem occurs because it is literally impossible (as yet) to discover the effect of environment on heredity and to what extent environment may change or modify the effect of certain gene pairs. The reasons listed below make the study of genetics more difficult than the areas of plant and animal genetics:

Difficulties in Studying Human Heredity

1. Biologists cannot set up controlled breeding experiments with humans as they can with fruit flies.

2. Suppose people were to participate in controlled breeding experiments. It would still be difficult to discover whether a trait is dominant or recessive, as Mendel did, because no completely pure strains of humans exist. Migration, war, changing social and religious ideas, and easy means of transportation have led to many mixed matings.

3. It takes a long time for humans to mature and have offspring. Even if individuals were to marry at the early age of twenty, and even if their children and grandchildren were to marry at twenty also, only three or four generations could be traced during the normal life span of an investigator.

4. Although a family of eight people is considered large, it is small compared to the family of 200 or 300 produced by a pair of fruit flies. The number of offspring in human families is generally small. Thus, it is difficult to obtain reliable ratios of traits and, thereby, to determine the number and types of genes involved in a trait that is being investigated. In turn, it then becomes difficult to determine whether the genes are linked or whether crossing-over has occurred.

5. Since very few families keep complete and accurate records of births, deaths, the appearance of a new trait, or the disappearance of an old trait, it is difficult to obtain an accurate description of the phenotypes of ancestors.

6. Because of the reluctance of a family to reveal the number of relatives who died of cancer, who suffer from asthma, etc., who died in insane asylums, or who married outside their race, it if often impossible to get information regarding inheritance of certain traits.

7. Recall the 46 chromosomes that are present in humans. These chromosomes are small and not easily studied. Also, the sequence of genes in the chromosomes is relatively unknown.

With all these drawbacks, human genetics is the topic which usually gets us most interested because it is most directly connected to us!

A. True or False? Heredity or Environment?

OBJECTIVES

When you finish, you should be able to:

1. determine the percentage of a survey population who are aware of the validity of many well-known inheritance beliefs.

2. draw conclusions concerning the effect of environment or modifying genes on human characteristics such as eye color and mental ability.

ACTIVITIES

a. Do "Genetic Facts and Fallacies" (on separate sheet in packet or to be obtained from your teacher).

b. Read "Idea Bridge: Heredity AND/OR Environment" (on separate sheet in packet or available from your teacher).

c. Do "Human Characteristics: Heredity or Environment?

9-1
GENETIC FACTS AND FALLACIES

Purpose

To determine the extent to which some basic genetic principles and concepts are understood.

Related Information

Have you ever heard anyone say that the male is the stronger of the two sexes and that he controls the heredity of the child? Or have you heard anyone suggest that an expectant mother attend concerts if she wants her unborn child to become a musician? Through our knowledge of genetics, we have learned that the mother does not influence her unborn child, nor does the father alone control its heredity. In this survey you will determine the extent to which members of your family and your friends believe various statements concerning inheritance.

Part 1 CONDUCTING THE SURVEY

The following statements relate to various genetic principles, many of which are associated with common false ideas and superstitions. Certain of the statements are true. Others are false. The purpose of the survey is not to test you, but to provide a questionnaire for you to use.

Materials

no materials or apparatus required

Procedure and Observations

Select ten or more people of various ages and read each of the 20 statements. Ask each person if he believes the statements to be true or false. Tabulate the answers given after each statement and show the total number of subjects who responded to each statement. Be careful not to indicate the answer in reading the statement. Correct answers to all survey statements are given in the chart on the following page.

	True	*False*	*Total*
1. Certain acquired characteristics, such as mechanical or mathematical skill, may be inherited.			
2. Identical twins are always of the same sex.			
3. Fraternal twins are more closely related to each other than to other children in a family.			
4. The father determines the sex of a child.			
5. Each parent contributes half of a child's genetic makeup.			
6. Certain thoughts or experiences of a mother may mark or alter the hereditary makeup of an unborn child.			
7. Color blindness is more common in males than in females.			
8. A person may transmit characteristics to offspring which he, himself, does not show.			
9. Certain hereditary characteristics are influenced by the blood.			
10. Identical twins are more closely related than fraternal twins.			
11. Certain inherited traits may be altered by the stars, moon, or planets early in development.			

12. Males are biologically stronger than females.
13. The tendency to produce twins may run in families.
14. A craving for a food such as strawberries may cause a birthmark on an unborn child.
15. Many of a person's inherited traits are not apparent.
16. The parent with the stronger will contributes more to a child's inheritance than the other parent.
17. If a person loses a limb in an accident, it is likely that he or she will have a child with a missing limb.
18. The attitude of parents toward each other influences the emotional makeup of an unborn child.
19. Children born to older parents usually lack the vitality of those born to younger parents.
20. The total number of male births exceeds female births each year.

True	*False*	*Total*

Part 2 TABULATING THE RESULTS

In this part you will gain some experience in tabulating data from a number of different sources. Raw data, such as you have collected, does not serve a purpose until put into a useful figure. The percentages obtained will be graphed to provide a visual representation of the data collected by the class.

Materials

1/4 in. square graph paper
2 colored pencils

Procedure and Observations

In the chart below, indicate your number of correct and incorrect answers to the left of each square. Leave space to add the total correct and incorrect responses of the class. The sum of the total responses should be the same for all of the survey statements.

	No. correct answers	*No. incorrect answers*	*Total responses*	*Correct answers (%)*	*Incorrect answers (%)*
1. False					
2. True					
3. False					
4. True					
5. True					
6. False					
7. True					
8. True					
9. False					
10. True					

	No. correct answers	*No. incorrect answers*	*Total responses*	*Correct answers (%)*	*Incorrect answers (%)*
11. False					
12. False					
13. True					
14. False					
15. True					
16. False					
17. False					
18. False					
19. False					
20. True					

Summary

To what extent does the survey indicate a need for additional information in genetics? .....

.....

.....

.....

.....

Idea Bridge: Heredity AND/OR Environment

When we talk about something being "caused by heredity" or "caused by environment" do we really mean what we say? We are quite willing to recognize that heredity plays an important part in the development of domestic animals and plants. We would not expect a Great Dane dog to produce a litter of terriers; nor would we expect seeds from a yellow tomato to produce plants that would bear red tomatoes. We recognize, of course that environment plays a part, too. We feed the livestock on our farms, train our horses and dogs, and fertilize our fields. All of these activities are part of the environment. We could not produce our domestic animals and plants without them. We know that heredity and environment must necessarily interact.

When we think and talk about people, however, we do not always remember this necessary interaction. We know that physical traits are inherited. These include things like eye color, height, type of body build, skin color, curly and straight hair. But are all of these due entirely to heredity? For example, from the standpoint of heredity, a certain boy would be able to grow to be six feet tall. When he is five years old, however, he is very ill, and that year he grows only half the normal amount. Normally he has been growing about two inches a year. That year he grows only one inch. He never makes up the inch that he did not grow in that particular year. There is a time and a place for each step in development. If it does not take place at that time, it never does takes place. The boy's adult height is only five feet and eleven inches.

Could this be true of something like eye color? Yes, it could. Again for example, a child inherits the ability to develop dark brown eyes. The dark pigment is called melanin. It may be found in eyes, skin, and hair, making the person who has it dark. If the formation of the dark pigment should require the availability of a particular chemical trace element in the food, the lack of this trace element would stop the development of the pigment. We know about such a relationship in the development of the thyroid gland, and its secretion, thyroxin. If iodine is not present as a trace element, the gland and its secretion do not develop normally. Something of the same kind could happen in the case of melanin.

The characteristics that we would like most to believe are primarily dependent on the environment are mental abilities and personality traits. These are the areas where it is most important that people be considered "equal". Society can do something about these traits through education and improved environment and make itself better in the process.

It is difficult, however, to see how even these traits could develop from environment alone. Any behavioral trait is dependent finally on the nervous system and/or the glands of internal secretion (endocrine glands). It has to have a physical basis in the anatomy and physiology of these body systems to exist at all. When we ask ourselves what kind of basis this is, we come to the structure, size, number, arrangement and chemical make-up of the nerve cells and secreting cells. All of these have to be based finally in heredity. This is what the individual starts out with.

What the individual starts out with is modified by (1) the environment of the embryo before birth, (2) the environment of childhood and youth, and (3) the everyday environment in which the individual lives. However, environment cannot create a characteristic from nothing. It has to have some basis on which to work. Likewise, heredity cannot operate in a vacuum. It has to have an environment in which to work. Therefore, environment and heredity have to interact.

Human Characteristics: Heredity or Environment?

Introduction:

There are some human characteristics which are readily recognized as having a hereditary basis: eye color, curly hair, facial features, height, and body build, for example. Others, such as suseptibility to disease, are less widely accepted as being related to heredity. Still others, including personality traits, general mental ability, and various special abilities (such as music, art, mechanics, and mathematics) are thought by many people to be due mostly, if not entirely, to environment.

In this laboratory experience we will examine a physical trait, and ask ourselves if environment could in any way influence its expression. Then, we will examine a trait of behavior and ask ourselves if it could have a hereditary basis.

Materials and Equipment:

No materials or equipment are necessary for the first part of this laboratory experience. For the second part the following are necessary:

Puzzle

Tags

Collecting Data:

The inheritance of eye color in humans is ordinarily presented as being based on two kinds of hereditary determiners or genes: brown and blue. There is a single pair of these. The pair may consist of two brown genes, two blue genes, or one brown gene and one blue gene. The brown gene is stronger than the blue, and is dominant over it when the two are present together. Therefore, two browns, or a brown and a blue, will produce brown, while only two blues together will produce blue. There is no question that this pair of genes exists. And there is no question that it is the principal basis for determining eye colors. But is this the whole story?

The color of eyes in humans is due principally to the amount of one pigment, melanin, which is present. This is a dark pigment, which is also found in hair and skin. Albinos, who have a gene for total absence of color in skin, hair and eyes, never develop any dark pigment in their eyes. Their eyes are pink, because of the blood vessels that show through. Have you ever seen pink-eyed white rabbits? Background coloration may result in a very light blue in the eyes of human albinos.

In all other people some melanin is deposited. The depositing of melanin takes place in the iris of the eye. It begins at a particular point of time in the development of the embryo, and it ends at a point which differs in individuals. Darker eyed persons are those in whom the depositing of melanin goes on faster and/or for a longer time. Heredity factors serve to determine the rate and timing

of the process of pigment deposition. Sometimes the process is completed before birth or shortly afterward. These people remain blue-eyed. Sometimes it continues into childhood, or even into adulthood. These people become hazel-eyed or light brown-eyed or dark brown-eyed.

Observe closely the colors of the eyes of all members of your class. Is it possible to classify all of them as either "brown" or "blue"? Try to put them into the smallest number of color groups that is possible. How many color groups are necessary? Try out your color groups by attempting to classify the same number of persons outside your class. Do you find any individuals who do not fit into any of the groups? If you do, you will need to revise your classification, and possibly create a new color group. Continue to try out and revise your classification until you are sure that you can use it to classify any person whom you might meet.

Now line up the members of your class in such a way that they form an eye-color gradient, from the person with the darkest eyes to the person with the lightest eyes. Can you draw a line between "brown" and "blue" on the gradient? Where does "brown" stop and "blue" begin? Is there a gradient within the brown range, and within the blue range (some darker and some lighter)? What about the color groups which you have identified between brown and blue?

Do you think that a single pair of brown-blue genes is sufficient to account for human eye color? Would it be possible with a single brown-blue pair to have colors other than one shade of brown and one shade of blue? One possible explanation of the other color groups would be the existence of modifying genes (intensifying genes and diluting genes). Another would be the influence of the environment, modifying the action of a single pair of genes. Which do you think is the most likely explanation? Why?

The second part of the experience has to do with the development of a simple skill. Students will each get a puzzle made from a 3" x 5" filing card from the teacher. They will also each draw a tag with a number. The tags will be numbered, beginning with (1), to correspond to the number of students in the class.

Students will contest in pairs. As many pairs may contest at a time as there are umpires to watch them. Students who are not contesting at a particular time may serve as umpires. In each contest the student who gets the puzzle together first is the winner.

Each student will contest three times in each series of trials. For the first trial, the pairs numbered (1) and (2), (3) and (4), (5) and (6), (7) and (8), and following, will contest. For the second trial numbers (1) and (3), (2) and (4), (5) and (7), (6) and (8), and following will contest. For the third trial, numbers (1) and (4), (2) and (3), (5) and (8), (6) and (7), and following will contest. Students losing all three of the contests will retire from the game.

The numbers should be collected at this point. The remaining students who are still in the game will draw new numbers in a series beginning with (1). They will repeat the process, each contesting three times in the same numerical order as before, using the same puzzle. Again the three-time losers will retire from the game.

Additional contests following the same pattern will continue until all students except one have been eliminated. This remaining student will be declared the winner. If more than one class group has been engaged in the same laboratory experience, the "champion" of one class group may contest with the "champion" of another. This may be done if the same puzzle has been used in both classes. If different puzzles have been used, the situation would not be comparable. Why not?

How is this laboratory experience like competition in business or politics? How is it different? Is success in these fields based in part on inherited ability? Or is it entirely a matter of hard work? Or luck? If a part of it is based on good home background, how much of this, in turn, is due to inherited ability in the family line?

How much do you think inherited ability had to do with winning this contest? How much do you think environment had to do with it? What kind of hereditary factors, if any, could have been operating? How do you think environment could have operated to contribute to the result? Which do you think was most important, heredity or environment? Why?

Follow-Up:

What about other human traits? What about susceptibility or resistance to respiratory disease? Heart disease? Cancer? Mental disorders? What about personality traits? What about high temper? Moodiness? Criminal tendencies? What about special abilities? What about musical ability? Artistic ability? Mechanical ability? Mathematical ability? Ability to learn languages easily?

To what extent do these traits have a hereditary basis? To what extent are they due to environment? Is it possible for any traits of this type to develop without some interaction of both heredity and environment? Does the relative importance of heredity and environment always have to be the same in the case of different traits?

B. Chance or Choice?

OBJECTIVE

When you finish, you should be able to:

3. determine the possible gene combinations in a fertilized egg cell based on probability.

ACTIVITIES

a. Do "Determination of Ratios in Chance Combinations" (on separate sheet in packet or available from your teacher).

b. Read "Models for Probability: Heredity" (on separate sheet in packet or available from your teacher).

9-4
DETERMINATION OF RATIOS IN CHANCE COMBINATIONS

Purpose

To study the chance distribution of genes in eggs and sperms resulting from meiosis during oogenesis and spermatogenesis.

Related Information

The study of genetics reveals that hereditary traits are determined by specific areas of a chromosome called genes. Genes are arranged in linear order on the chromosome and occur in pairs, as do the chromosomes. Chance distribution of chromosomes during meiosis and their recombination during fertilization account for the many variations that occur in offspring.

Part 1 DEMONSTRATION OF THE CHANCE COMBINATION OF GENES DURING FERTILIZATION

In this part you will study the random, or chance, combination of two kinds of beans. There are only three possible combinations these beans can make. This represents what actually occurs during fertilization when a gene pair lying on two homologous chromosomes recombines after being separated during meiosis.

Materials

eight boxes
800 red beans
800 white beans

Procedure and Observations

The class should be divided into four sections for this activity. Each section will have two boxes of beans. Each box contains a mixture of 200 red beans and 200 white beans. Label one box to represent the genes contributed by the sperm and the other to represent genes contributed by the egg.

Since the egg and the sperm each contribute one gene of a single pair, choose a bean from each box in order to have a gene pair. Lay the gene pairs in rows: red-red, red-white, and white-white. Select your beans in a series of rounds which will be timed by your teacher. After each round, count the beans in each row and record in the table provided.

Round	*Number of pairs of beans in:*			
	Row 1 red-red	*Row 2 red-white*	*Row 3 white-white*	*Total pairs*
Section 1				
Section 2				
Section 3				
Section 4				
Class Totals				

On the basis of the data you collected, it is possible to calculate the ratios for each type of gene pair. Add the totals of your three rows and divide the sum by four. (The *four* represents the reduction that occurs in the formation of the egg and sperm during meiosis.) Then, divide the quotient into the total for each row. The number you obtain expresses a ratio. A sample of this calculation is given in the diagram.

37 + 86 + 41 = 164
164 ÷ 4 = 41
37 ÷ 41 = 0.9
86 ÷ 41 = 2.1
41 ÷ 41 = 1.0

Ratio .9 red-red;
2.1 red-white;
1.0 white-white

Calculation of ratio

(a) What ratio did you obtain? .....

..... (b) Why is it necessary to have so many beans in each box? .....

(c) Explain why the number of each color is constant in all boxes.

.....

(d) Why was it necessary to select so many pairs? .....

..... (e) What were your chances of selecting the same color beans in a gene pair? ..... (f) A different color? ..... (g) Explain why it was important to use two different colors. .....

(h) What genetic principles are demonstrated by your bean selection? .....

Summary

How does chance selection of genes provide the basis for variations in organisms? .....

.....

.....

.....

Models for Probability: Heredity

Introduction:

Have you ever wondered why some people have blue eyes and some have brown eyes? Or why some people have curly hair and some straight? Or why some people are tall and others short? Or why some people have skin of one color and some another? Characteristics of people depend on the heredity factors that they carry. When these heredity factors are combined in the offspring of two parents they behave in the same way that coins do when they are tossed.

Heredity factors are called genes. They exist in pairs. When the germ cells that contain the genes get ready for fertilization, the members of each gene pair separate. Each member of the pair goes into a different germ cell.

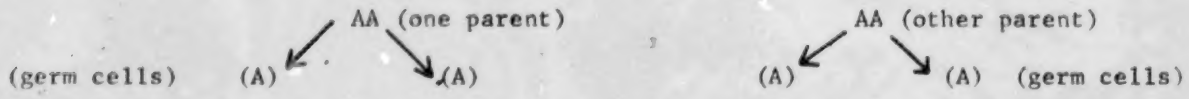
The germ cells from the two parents (sperms from the male and ova or eggs from the female) are united at the time of fertilization to form a new individual. Each parent contributes one member of each pair of genes. The new individual therefore starts out in life with one member of each pair of genes from the father and one from the mother.

Although some characteristics, like height and skin color, are determined by several pairs of genes working together, many characteristics are determined by a single pair of genes. An example of a characteristic determined by a single pair of genes is curly hair.* A curly-haired individual carries two genes for curly. We will use "AA" as a model for curly hair. A straight-haired individual has two genes for straight. We will use "aa" as a model for straight hair. An individual with one gene for curly and one gene for straight (model "Aa") has wavy hair.

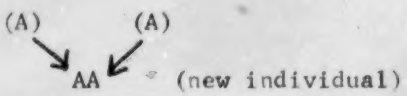
If a curly haired person marries another who is also curly-haired, we can use this as a model to represent their marriage:

AA X AA

When the members of the gene pair separate before fertilization and go into separate germ cells, the model looks like this:



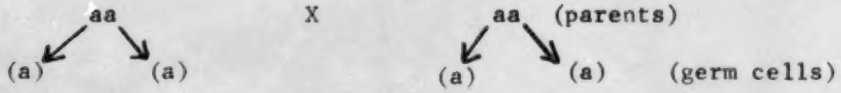
Note that all germ cells of both parents contain a single gene: (A). When the germ cells unite at fertilization this is the model:



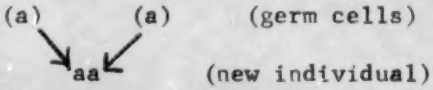
*This is true for Caucasoid (so-called "white") people. Mongoloid people (Chinese, American Indians and others) have only straight hair. Negroid (brown and black) people have a gene for curly which is so strong that it prevents the expression of all other hair genes.

All of the new individuals contain two genes for curly, and all of them are curly-haired.

The same kind of thing happens when two straight-haired individuals marry:



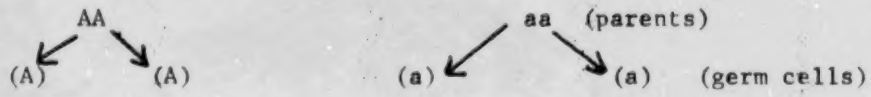
When the germ cells unite at fertilization, all of the new individuals contain two genes for straight, and all of them are straight-haired.



When a curly haired individual marries a straight-haired individual:

AA X aa

All of the germ cells from the curly-haired parent carry only curly genes, and all of the germ cells from the straight-haired parent carry only straight genes:



At fertilization curly genes have to unite with straight genes:

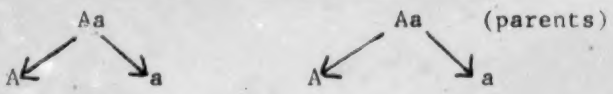
(one germ cell from each parent)

and the new individuals that are formed are all Aa, and are therefore wavy-haired.

What happens if a wavy-haired person marries another wavy-haired person?

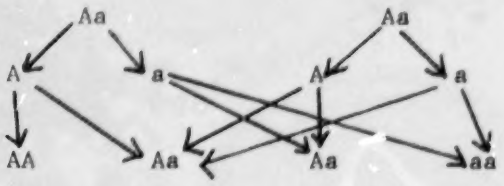
Aa X Aa

When the gene pairs separate:



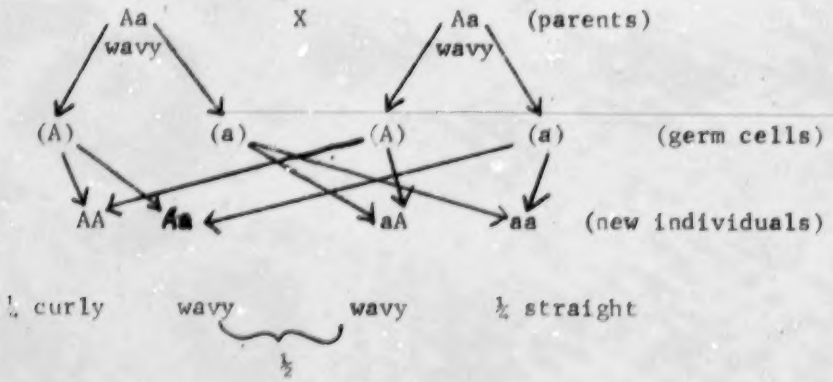
Half of the germ cell from each parent carry curly half carry straight.

When fertilization takes place, there is an equal chance of a curly gene from one parent combining with either a curly or straight gene from the other parent. And there is the same chance of a straight gene from one parent combining with either a curly or straight gene from the other parent:



Thus there is one chance in four of a new individual that is curly-haired, two chances in four of new individuals that are wavy-haired, and one chance in four of a new individual that is straight-haired. With a large number of new individuals you could expect a ratio of ¼ curly, ½ wavy, and ¼ straight.

Let us now look again at what happens when a wavy-haired person marries another person with wavy hair, and pull it together into a single picture:



This picture is a mathematical model. Another way to show it is with this model:

(germ cells of one parent)	A	a
A	A A	A a
a	a A	a a

(germ cells of the other parent)

(new individuals)

The four kinds of recombinations that take place in the new individuals occur in equal numbers:

¼AA ¼Aa ¼aA ¼aa

Two of them, however, (Aa and aA) are really the same. Therefore, the result is a ratio of 1:2:1.

C. Genetic Laws in Human Populations

OBJECTIVES

When you finish, you should be able to:

4. investigate certain human traits and determine their frequency in a population.

5. relate Mendel's laws to human genetic traits.

6. construct, read and interpret a family history for a specific genetic trait.

ACTIVITIES

a. Read Chapter 11 in Modern Biology, 1969 edition (or other reading material assigned by your teacher).

b. Do "What are some dominant and recessive traits in man?" (on separate sheet in packet or available from your teacher).

c. Do "Problems" (on separate sheet in packet or available from your teacher).

d. Do "Frequency of Human Genetic Traits" (on separate sheet in packet or available from your teacher).

Name _____ Class _____ Date _____

ACTIVITY 30. What are some dominant and recessive traits in man?

PRE - LAB

Have you ever heard it said that someone "looks just like" a close relative? Probably you have. Possibly you've heard expressions like "he has his father's eyes" or "his mother's nose". What lies behind such statements?

The answer to this question is heredity. We know that many human traits are inherited, and the features of the face are good examples. Many human traits are determined by the interaction of a number of genes, and the environment as well. For instance, the appearance of the nose can depend on the height of the bridge, the shape and size of the nostrils, and the size of the tip. Past accidents have their influence, too.

The greater the number of genes that interact to product a trait, the more difficult it is to determine how it is inherited. But some human characteristics are passed down the way tallness and shortness were in Mendel's pea plants: as simple dominants and recessives. They are determined by one or the other of a contrasting pair of genes. We call the different genes which determine a trait alleles (a-leelz). The genes for tallness and shortness, for example, are alleles for height in garden pea plants.

Among human traits which are inherited as dominants and recessives are many which can't be studied simply by looking at them. For example, the gene for type A blood is dominant over that for type O, but you have to test for blood groups. What are some visible human traits that are inherited as simple dominants and recessives? For the answer to this question, you have only to look at your relatives, your friends -- and yourself.

To begin with, examine the ear lobe, the lower, fleshy part of the ear, in a number of your classmates. Very soon you will recognize that there are two basic types, the free ear lobe and the attached. Free ear lobes hang down next to the jaw, while attached lobes run directly into it. Which trait is the dominant one?

Similarly, some people have dimples in one or both cheeks, while others have NO dimples. In some people the hair at the middle of the forehead forms a point called a widow's peak. In others the widow's peak is absent and the hairline is smoothly curved. Some people have a deep cleft (a grocve) in their chin; others don't. Some people can stick out their tongues and roll them up at the sides, while others can only stick them out and no more.

On the next page you'll find a simple procedure for conducting your own inquiry into human heredity. But before you go on, answer these questions.

QUESTIONS

1. Human traits are determined by heredity and _____.

2. What is dominant trait? _____

_____

3. What is a recessive trait? _____

_____

4. What is an allele? _____

5. How do free and attached ear lobes differ from each other? _____

_____

LABORATORY PROCEDURE

1. Choose one trait from among the five that are described in the Pre-Lab section for your investigation. (Other students in your class will investigate either the same trait or one of the others suggested. Your teacher can assign different traits to various class members.)

2. Examine as many members of as many families as you can for the trait you are investigating. Include as many generations as you can of each family in your study.

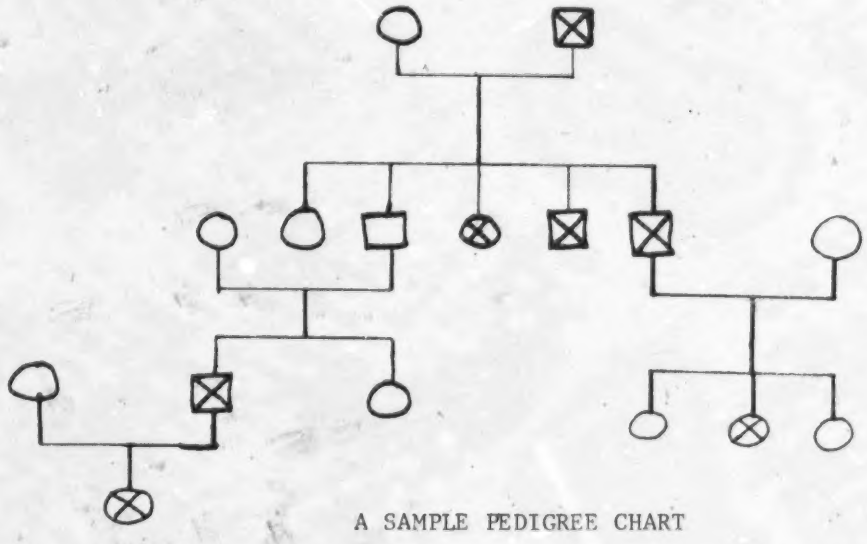
3. Prepare a pedigree chart for each family showing the form of the trait in each member. Use this key:

0 = female ▭ = male

Ⓧ or [X] = trait present (or name the form of the trait present)

0 or ▭ = trait absent

Marriages and offspring in your pedigree chart should be represented as shown in the sample pedigree chart below.



A SAMPLE PEDIGREE CHART

OBSERVATIONS

1. Write the key you are using for your investigation in the space to the right. Be sure to give the meaning of each symbol.

KEY USED FOR INVESTIGATION

2. Draw a pedigree chart below for each family you have investigated. Have you included all members of each family where possible?

PEDIGREE CHARTS

POST - LAB

1. For the human trait you have investigated, which form do you think is dominant?

2. Explain your answer to Question 1.

3. Which form of the trait did you observe to skip a generation? (If neither one did, which could have?)

4. What would be the expected genotype and phenotype ratios among the offspring of the marriages listed in the table below for the trait you studied?

EXPECTED GENOTYPE AND PHENOTYPE RATIOS OF OFFSPRING

CROSSES (MARRIAGES)	GENOTYPE RATIO	PHENOTYPE RATIO
Pure dominant X pure dominant		
Pure dominant X pure recessive		
Hybrid X hybrid		
Hybrid X pure dominant		
Hybrid X pure recessive		

5. Why don't your results agree with the ideal expected ratios?

6. How does investigating several families help you to get results that are closer to the ideal ratios?

7. Why is it so important to study as many members of each family as possible?

Make a record of a family known to you in which some interesting characteristic appears in several members. Record it in the form of a pedigree chart. Answer as many of the following questions about the character as you can:

1. Is the character clear-cut, so that a person either has it or does not have it, or are there various degrees of expression ranging from one extreme to the other?

2. Does it occur in both males and females, and if so, do both sexes show it with approximately the same frequency?

3. Does it ever appear in a son or daughter when neither parent showed it?

4. When both parents have the character, do all the children show it?

5. Would the expression of the character be easily influenced by changes in the environment?

6. If the character could be influenced by the environment, do you think it might still have a hereditary basis?

7. File away the pedigree you have recorded, and after you have completed the study of genetics, examine it again and determine what kind of hereditary behavior, if any, appears to be concerned in the transmission of the character.

8. List some human characters which might be readily influenced by changes in the environment. Suggest the environmental changes which might be expected to influence each.

9. List some human characters which would probably not be easily influenced by changes in the environment.

10. List some human characters which do not appear until late in life. Would such characters be relatively easy or difficult to study from the standpoint of heredity? Why?

11. List some human characters which vary considerably in the degree of their expression from person to person. In beginning the study of heredity, would such characters be the most favorable kind for study? Give reasons for your answer.

12. List some characters in domestic animals or pets which you have observed to be apparently dependent upon heredity. Why would it be easier to learn the fundamental principles of heredity from the study of animals and plants then from the study of human beings?

11-1
FREQUENCY OF HUMAN GENETIC TRAITS

Purpose

To study the inheritance of certain human traits and to determine their frequency in a population.

Related Information

In studying human genetics it is not possible to determine the results of experimental crosses, as it was for Mendel in his study of garden peas. It is possible, however, to sample a human population to determine the frequency of a given trait and the way it is inherited.

Part 1 INHERITANCE OF THE ABILITY TO TASTE PHENYLTHIOCARBAMIDE

The ability or inability of an individual to taste PTC as a bitter sensation is genetically determined. About 70 percent of the population are PTC tasters, and about 30 percent are nontasters.

Materials

PTC (phenylthiocarbamide) papers

Procedure and Observations

PTC papers are used in this part to determine whether members of the class and their families are tasters or nontasters. Put one of the PTC papers in your mouth. Can you taste it? Record your results in the table provided.

Reaction	*You*	*Your family*	*Class*	*Families of class*	*Total*	*Ratio*	*Ratio expressed as decimal*
Taster							
Nontaster							
Total							

Take some of the PTC papers home and test members of your family. Record each member as a taster or nontaster. Complete the table provided, recording the results of the class test, the members of their families, the ratio of tasters to nontasters, and the ratio expressed as a decimal. (a) On the basis of your results, can you determine whether the ability to taste PTC is due to a dominant or a recessive gene? .....

(b) If so, is the ability to taste PTC dominant or recessive? .....

(c) Could two parents who are nontasters have a child who is a taster? ..... (d) Explain your answer. .....

..... (e) Could a parent who is a taster and one who is a nontaster have children who are tasters? ..... (f) Explain your answer. .....

.....

..... (g) Could the parents in (*e*) have children who are nontasters? ..... (h) Explain your answer. .....

.....

Prepare a pedigree of your family's ability to taste PTC.

Part 2 INHERITANCE OF THE ABILITY TO ROLL THE TONGUE

The ability to roll the tongue is inherited as a dominant trait. People either roll the tongue easily or not at all.

Materials

no materials or apparatus required

Procedure and Observations

First determine whether you can roll your tongue and record the result in the table. Now determine the ability of the members of your class to roll their tongues and record the result in the table. Check the members of your family to determine whether they have the inherited ability to roll their tongues. Prepare a pedigree of the inheritance of the trait in your family.

Count the occurrence of the trait among ten individuals in your community. *Be sure that no other member of the class has counted them in their sampling.* Record your results in the table.

(a) How close is your ratio to the 3:1 ratio Mendel found in making monohybrid crosses with simple dominance? ..... (b) If the ratio is not close to 3:1, give a possible explanation. .....

..... (c) Are all the tongue rollers in your survey homozygous for the trait? ..... (d) Explain your answer. .....

.....

Trait	*You*	*Your family*	*Class*	*Families of class*	*Total*	*Ratio*	*Ratio expressed as decimal*
Tongue roller							
Nonroller							
Total							

Summary

Compare the results of the PTC survey with the tongue roller survey. .....

.....

.....

.....

.....

D. More Human Inheritance

OBJECTIVES

When you finish, you should be able to:

7. diagram and explain how these factors are inherited in humans.

   a. blood types (A, B, O and Rh factor)
   b. red - green color blindness
   c. hemophilia
   d. baldness
   e. eye and skin color
   f. Down's Syndrome
   g. phenylketonuria

8. work genetic problems in human genetics encompassing all genetic laws.

ACTIVITIES

a. Do "Inheritance of Blood Types" (on separate sheet or available from your teacher).

b. Do "Sex-Linked Inheritance" (on separate sheet or available from your teacher).

c. Do "Human Gentics Problems" (on separate sheet or available from your teacher).

d. Reread Chapter 11 of Modern Biology.

e. Do the Crossword Puzzle on Heredity.

11-2

INHERITANCE OF BLOOD TYPES

Purpose

To demonstrate and become familiar with the inheritance of blood types in humans.

Related Information

Geneticists probably know more about blood types than any other inherited human trait. The four basic blood types are determined by the presence or absence of the A and B agglutinogens in the red corpuscles. For clarity, consider blood types as being determined by a single pair of genes. Thus, type-A blood may be homozygous I^AI^A or heterozygous I^Ai. Type-B blood may be homozygous I^BI^B or heterozygous I^Bi. Type O blood must be homozygous ii, and type-AB is a combination of A and B antigens, with the genotype I^AI^B, illustrating codominance.

Part 1 DIAGRAMMING INHERITANCE OF BLOOD TYPES

In this part you will diagram the inheritance of blood type in the offspring of parents each having blood of a different type.

Materials

no materials or apparatus required

Procedure and Observations

Using the Punnett square shown and the genotypes given above, cross a parent heterozygous for type-A blood with another having type-AB blood.

(a) What is the genotype of the parent having type-A blood? ..... (b) What is the genotype of the AB parent? .... (c) What genes for blood type may be passed on from the type-A parent to the offspring? ..... (d) From the type-AB parent? ..... (e) What gene combinations might be inherited by the offspring? .....

A → Parents AB ↘		

(f) What blood types might the offspring possess? .....

(g) What blood types are not possible in the offspring? ..... (h) Are any of the offspring homozygous for a type of blood? ..... Which type? .....

(i) Are any of the offspring homozygous for the recessive allele? ..... (j) Is the gene for the recessive allele present in any of the offspring? ..... (k) What blood type does that offspring possess? ..... (l) What percentage of offspring might be expected to have the same blood as the type-A parent? ..... (m) As the AB parent? .....

Part 2 DETERMINING BLOOD TYPE POSSIBILITIES IN OFFSPRING

In this part you will become familiar with the blood types that are possible in offspring resulting from the crossing of parents having different bloodtypes.

Materials

no materials or apparatus required

Procedure and Observations

Using the table provided, determine all possible genotypes of the parents, all possible genotypes of the children, all possible blood types, and blood types *not* possible in the children.

Blood type of parents	*All possible genotypes of parents*	*All possible genotypes of children*	*All possible blood types of children*	*Blood types not possible for children*
A and O				
B and O				
A and B				
AB and A				
AB and B				
AB and O				
O and O				

Summary

(a) On the basis of data in the table, could you prove that a child belongs to a certain set of parents?

..... (b) Explain. .....

.....

(c) Could you prove that a certain child did not belong to a particular set of parents? .....

..... (d) Explain. .....

.....

(e) Why is it impossible to determine whether a child belongs to a certain set of parents, but possible to determine whether he does not? .....

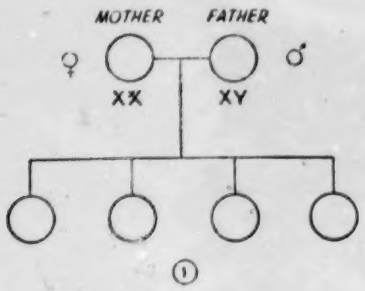
.....

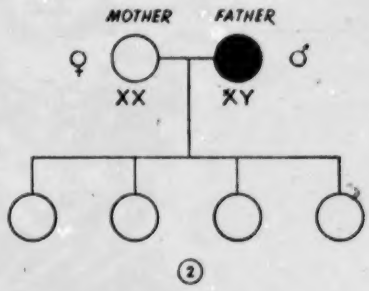
.....

16. SEX-LINKED INHERITANCE

The X and Y chromosomes, which carry the genes which determine sex, also carry genes for other traits. Such traits are said to be *sex-linked*. The likelihood of having one of these sex-linked traits sometimes depends on whether the individual is male or female; in a female, a recessive gene in one X chromosome can be masked by its dominant in the other X chromosome, but a male who inherits this gene in his single X chromosome will show the characteristic. Color blindness and hemophilia are two human defects produced by recessive genes carried by the X chromosome. They may be transmitted through many generations of normal females, appearing only in some of the male offspring.

The following diagrams show that a female with normal color vision may transmit color blindness to some of her sons, but that all the children of a color blind father will have normal vision if the mother's color vision genes are both normal.





1. In Diagram 1, the parents are a father with normal color vision and a mother (with normal vision) carrying the color blindness gene. Show the combinations which may appear in their children by lettering each circle in the F_1 generation. Indicate sex by the symbols ♀ and ♂. Indicate color blindness by filling in the circle with black.

2. What percent of the daughters have normal color vision? ..... What percent of the sons? ..... What percent of the daughters carry the color blindness gene? .....

3. In diagram 2, the father is color blind. Complete the diagram.

4. What percent of the daughters have normal vision? ..... What percent of the sons? ..... What percent of the daughters are carriers of the defective gene? .....

5. Under what circumstances could a female be color blind? .....

.....

6. Describe the color vision of the children of a color blind mother .....

.....

Note: In man, brown eyes are dominant over blue.

1. A brown-eyed man marries a blue-eyed woman and they have eight children, all brown-eyed. What are the genotypes of all the individuals in the family?

2. A blue-eyed man, both of whose parents were brown-eyed, marries a brown-eyed woman whose father was brown-eyed and whose mother was blue-eyed. They have one child, who is blue-eyed. What are the genotypes of all the individuals mentioned?

3. What are the chances that the first child from a marriage of two heterozygous brown-eyed parents will be blue-eyed? If the first child is brown-eyed, what are the chances that the second will be blue-eyed?

Note: In man, assume that right-handedness is dominant over left-handedness.

4. A right-handed, blue-eyed man whose father was left-handed marries a left-handed brown-eyed woman from a family in which all the members that have been brown-eyed for several generations. What offspring may be expected from this marriage as to the two traits mentioned?

5. A brown-eyed, right-handed man marries a right-handled, blue-eyed woman. Their first child is blue-eyed and left-handed. If other children are born to this couple, what will be their appearance as to these two traits?

6. A right-handed blue-eyed man marries a right-handed, brown-eyed woman. They have two children, one left-handed and brown-eyed and the other right-handed and blue-eyed. By a later marriage with another woman who is also right-handed and brown-eyed, this man has nine children, all of whom are right-handed and brown-eyed. What are the genotypes of this man and his two wives?

7. A girl of normal vision whose father was color blind marries a man of normal vision whose father was also color blind. What type of vision will be expected in their offpsring?

8. A color blind man marries a woman of normal vision. They have sons and daughters, all of normal vision and all of whom marry normal persons. Where among the grandchildren may color-blindness be expected to appear?

9. A man and woman, both of normal vision have (1) a color blind son who has a daughter of normal vision; (2) a daughter of normal vision who has one color blind and one normal son; and (3) another daughter of normal vision who has five sons, all normal. What are the probable genotypes of grandparents, children and grandchildren?

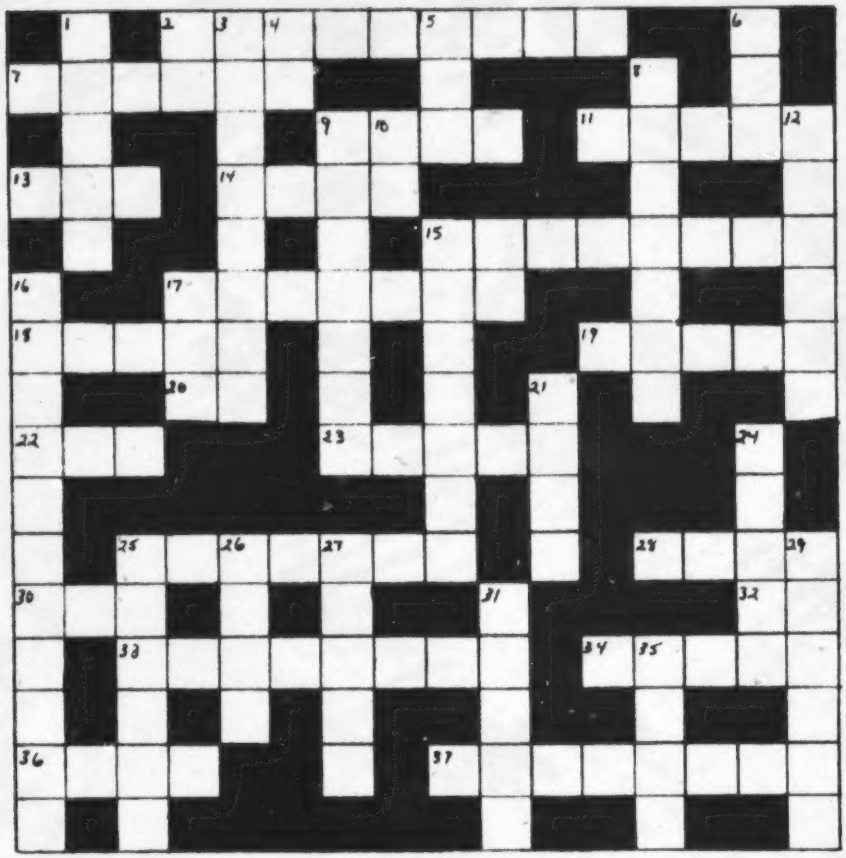
10. A man's maternal grandmother had normal vision; his maternal grandfather was color blind; his mother is color blind; his father is of normal vision. What are the genotypes, as to vision, of the two parents and grandparents mentioned? What type of vision has this man himself? What type have his sisters? If he should marry a woman genotypically like one of his sisters, what type of vision would be expected in the offspring?

Optional Problem

The mother of a right-handed, brown-eyed woman of normal vision is right-handed, blue-eyed and of normal vision. Her father is left-handed, brown-eyed, and color blind. This woman marries a man who is left-handed, brown-eyed, and of normal vision (whose father was blue-eyed). What chance will the sons of this couple have of resembling their father phenotypically?

CROSSWORD PUZZLE

HEREDITY



ACROSS

2 The substance of heredity is _____, found in the cell nucleus.
7 Gregor _____ formulated the laws of heredity.
9 A woman affected with hemophilia transmits it only to her _____ offspring.
11 Flowering state
13 The _____ of the offspring is determined by the chromosome in the sperm.
14 Level
15 A gene in a pair is _____ if it masks or prevents expression by the other.
17 The formation of body cells is called _____.
18 A bad _____ is sometimes blamed on heredity.
19 Fluid carrying sperm is _____.
20 An _____ chromosome combination produces a male offspring.
22 Identical twins begin life as _____ cell.

23 Primitive reproductive body
25 In reduction division, when a cell has one of each pair of chromosomes, or half, it is called _____ number.
28 The _____ is called the unit of heredity.
30 Utter
32 First and last letters of "oocyte".
33 A hollow sphere of cells in the development of the organism is called the _____.
34 A _____ is a mutant.
36 Revise for publication
37 When three layers are formed in cell division, we call it the _____ stage.

DOWN

1 The _____ on chromosomes carry certain hereditary traits.
2 Chance distribution (abbr.)
3 _____ influences an individual's makeup.
4 Fifth and seventh letters of 37 Across.
5 To be ill
6 The number of X-chromosomes possessed by the female.
8 Incomplete dominance results in _____ characteristics.
9 Type of cell reduction, in reproductive cells, to keep the chromosome number the same is _____.
10 Indefinite article
12 Offspring with characteristic not inherited but which can be passed on is a _____.
15 Full number of chromosomes in reproductive cell is _____.
16 A person has 23 pairs of _____.
17 Blend
21 Reproductive cell
24 _____-blindness is more common in men than in women.
25 An offspring from a cross between parents different in one or more traits is a _____.
26 Mendel carried out his experiments with garden _____.
27 An _____ matures into an egg, ready for fertilization.
29 Characteristics caused by mutations may cause death and are called _____ genes.
31 Pertaining to birth
35 _____ characteristics are those possessed by both parents and found in the offspring.

OBJECTIVES

At the end of this unit, the student should be able to:

1. determine the percentage of a survey population who are aware of the validity of many well-known inheritance beliefs.

2. draw conclusions concerning the effect of environment or modifying genes on human characteristics such as eye color and mental ability.

3. determine the possible gene combinations in a fertilized egg cell based on probability.

4. investigate certain human traits and determine their frequency in a population.

5. relate Mendel's laws to human genetic traits.

6. construct, read and interpret a family history for a specific genetic trait.

7. diagram and explain how these factors are inherited in humans:

    a. blood types (A, B, O and Rh factor)
    b. red - green color blindness
    c. hemophilia
    d. baldness
    e. eye and skin color
    f. Down's Syndrome
    g. phenylketonuria

8. work genetic problems in human genetics encompassing all genetic laws.

A. True or False? Heredity or Environment?

ACTIVITIES

a. from Biology Investigations by Otto, Towle, Otto, Holt, Rinehart & Winston, Inc.

Students will need survey sheet, graph paper and colored pencils.

For better sampling, survey should not include students enrolled in biology.

b. from E.S.E.A. Title III, Moline, Illinois

c. from E.S.E.A. Title III, Moline, Illinois

Students will need a puzzle in an envelope (unmarked). A series of numbered tags equal to the number of students in the class should be available for random selection by the student to determine his participation in the contest. (Puzzle pattern on separate sheet.)

B. Chance or Choice?

ACTIVITIES

a. from Biology Investigations by Otto, Towle, Otto, Holt, Rinehart & Winston, Inc.

It is possible to do this in smaller groups by using one person as a timer. The time alloted to each round should be consistent. 30-60 second rounds usually suffice.

You will need beans red and white of approximately the same size - counted after each round!

b. from E.S.E.A. Title III, Moline, Illinois

C. Genetic Laws in Human Populations

ACTIVITIES

a. Substitute another reading selection if necessary. Other books or editions of Modern Biology have similar information.

This also might be a good time for class discussion.

b. from Laboratory Activity Manual for Biology by Zeichner and Berman, College Entrance Book Company

c. from E.S.E.A. Title III, Moline, Illinois

Students should clear trait with you before researching it.

d. from Biology Investigations by Otto, Towle, Otto, Holt, Rinehart & Winston, Inc.

Need PTC test papers.

D. More Human Inheritance

ACTIVITIES

a. from Biology Investigations by Otto, Towle, Otto, Holt, Rinehart & Winston, Inc.

b. from Discovery Problems in Biology by Bagby, Cope, Hann and Stoddard, College Entrance Book Company

c. Thanks to Janet Owens, Catoctin High School.

d. Or other suitable reading material. At this point, selected questions might be a good review.

e. from E.S.E.A. Title III, Moline, Illinois

FILMS AND FILMSTRIPS

The two or three films available from the IMC are deadly and not recommended unless you have a superior group.

Bell Telephone's "The Thread of Life" is very good. Available from the Baltimore Office.

Another source is the National Foundation of the March of Dimes.

Address: Division of Health Information and School Relations
The National Foundation
Box 2000
White Plains, New York 10602

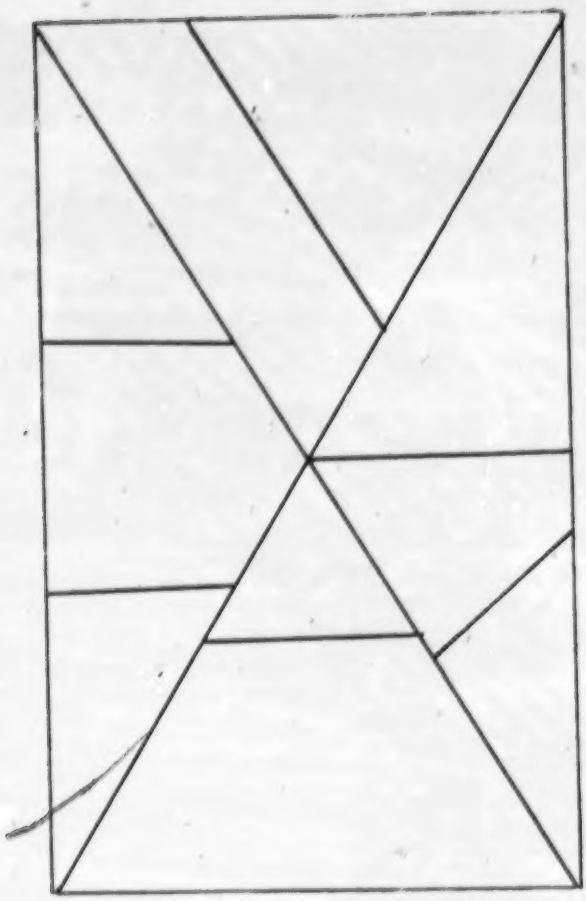
A word of caution: While it is always unadvisable to show films which are not previewed - it is especially so on the topic of genetics and birth defects. Preview and discuss films with your students to make them most effective.

BIBLIOGRAPHY

Otto, James H and Towle, Albert, Modern Biology, Holt, Rinehart & Winston, Inc., New York, 1969

Bagby, Grace; Cope, Harold; Hann, C.S. and Stoddard, Mabel, Discovery Problems in Biology, College Entrance Book Company, New York, 1961

Zechner, Irving and Berman, Paul, Laboratory Activity Manual for Biology, College Entrance Book Company, 1971



Puzzle Pattern for Part II, "Human Characteristics: Heredity or Environment"

Evaluation Form for Teachers

Name of mini-course _____

Evaluation Questions	Yes	No	Comments
1. Did this unit accomplish its objectives with your students?			
2. Did you add any of your own activities? If so, please include with the return of this form.			
3. Did you add any films that other teachers would find useful? Please mention source.			
4. Were the student instructions clear?			
5. Was there enough information in the teacher's section?			
6. Do you plan to use this unit again?			

7. Which level of student used this unit? _____

8. How did you use this unit - class, small group, individual? _____

_____

PLEASE RETURN TO SCIENCE SUPERVISOR'S OFFICE AS SOON AS YOU COMPLETE THE COURSE.

SCIENCE MINI-COURSES

PHYSICAL SCIENCE	Prepared by
ELECTRICITY: Part 1 (Types of Generation of Electricity)	Marvin Blickenstaff
ELECTRICITY: Part 2 (The Control and Measurement of Electricity	Marvin Blickenstaff
ELECTRICITY: Part 3 (Applications for Electricity)	Marvin Blickenstaff
CAN YOU HEAR MY VIBES? (A Mini-course on Sound)	Charles Buffington
LENSES AND THEIR USES	Beverly Stonestreet
WHAT IS IT? Identification of an Unknown Chemical Substance	Jane Tritt
BIOLOGY	
A VERY COMPLEX MOLECULE: D.N.A. The Substance that Carries Heredity	Paul Cook
Controlling the CODE OF LIFE	Paul Cook
Paleo Biology – BONES: Clues to Mankind's Past	Janet Owens
A Field Study in HUMAN ECOLOGY	Janet Owens
Basic Principles of GENETICS	Sharon Sheffield
HUMAN GENETICS – Mendel's Laws Applied to You	Sharon Sheffield
SCIENCE SURVEY	
WEATHER Instruments	John Fradiska
TOPOGRAPHIC Maps	John Geist and John Fradiska
CHEMISTRY	
WATER	Ross Foltz
PHYSICS	
PHYSICAL OPTICS	Walt Brilhart